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Choosing a Global Positioning System Device for Use in U.S. Army Corps of Engineers Regulatory Districts

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Choosing a Global Positioning System Device for Use in U.S. Army Corps of Engineers Regulatory Districts

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Abstract

Choosing a Global Positioning System (GPS) device for regulatory purposes involves tradeoffs between price, Corps-approved data transfer mechanisms, and accuracy. This report examines several devices representing different prices and accuracies and discusses accessories, such as external antennas, and software for the field and office. If a U.S. Army Corps of Engineers Regulatory District wants to purchase GPS units, we recommend they be one of the five devices described in this Special Report, depending on district needs, so that we are all using similar devices and can ensure appropriate levels of training and consistency.

GPS technology is constantly being upgraded and refined, ever enhancing our ability to accurately locate positions on the Earth's surface. The devices discussed here will be most useful for regulatory purposes within a few years of the publication date. This report will be updated as these devices become functionally obsolete.

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Contents

Abstract	ii
Figures and Tables.....	iv
Preface	v
Acronyms and Abbreviations	vi
1 Introduction.....	1
1.1 Background	1
1.2 Objectives.....	2
1.3 Approach	2
2 Types of Devices	3
2.1 Garmin.....	3
2.2 Magellan eXplorist 710 United States.....	6
2.3 Trimble Juno 5B Enhanced Wi-Fi and TDC100 Wi-Fi Handhelds	6
3 Recommendations.....	8
References	9
Report Documentation Page	

Figures and Tables

Tables

- 1 Summary of select specifications for Global Positioning System devices preferred for USACE Regulatory District tasks (n/a = not applicable, μ = micro, and HH = handheld, SD = 4 MB–2 GB memory card, SDHC [Secure Digital High Capacity] = 4 GB–32 GB memory card)..... 4
- 2 Comparison of data collection and office software Global Positioning System devices preferred for USACE Regulatory District tasks (n/a = not applicable) 5

Preface

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COL Bryan S. Green was the Commander of ERDC, and Dr. David W. Pittman was the Director.

Acronyms and Abbreviations

CRREL	Cold Regions Research and Engineering Laboratory
CX	Center of Expertise
ERDC	U.S. Army Engineer Research and Development Center
GIS	Geographic Information Systems
GPS	Global Positioning System
HH	Handheld
IWR	U.S. Army Engineer Institute for Water Resources
n/a	Not Applicable
NAE	U.S. Army New England Regulatory District
RS/GIS	Remote Sensing/Geographic Information Systems
SD	Secure Digital
SDHC	Secure Digital High Capacity
USACE	U.S. Army Corps of Engineers
WRAP	Wetlands Regulatory Assistance Program

1 Introduction

1.1 Background

Project Managers for the U.S. Army Corps of Engineers (USACE) Regulatory Districts use Global Positioning System (GPS) devices to collect geospatial data in support of the USACE mission to regulate dredging and filling of wetlands and Waters of the United States under Section 404 of the Clean Water Act (U.S. Congress 1977) and structures or work in navigable waters of the United States under Section 10 of the Rivers and Harbors Act (U.S. Congress 1899). In 2017, Regulatory Headquarters requested information summarizing the advantages and limitations of commonly used GPS devices to determine which devices are most suitable for regulatory purposes. This report is the result of that request. The information it contains will help standardize the geospatial data collected for Regulatory purposes, help ensure appropriate levels of training, and guide District purchases.

Choosing a GPS device for regulatory purposes involves tradeoffs between price, Corps-approved data transfer mechanisms (USACE 2016), and accuracy. Price is always an important consideration when making a purchase. The prices of the devices and supporting software discussed in this report reflect 2017 values. Efficient and secure data transfer mechanisms are also critical when choosing a GPS because USACE cyber security protocol prohibits GPS devices that accept flash media (e.g., SD [Secure Digital] cards) from being connected to CorpsNet computers (USACE 2016). The accuracy of the data collected is also extremely important. The real-time accuracies reported here are variable. Highest accuracies are achieved when a device is stationary, for example mounted on a tripod. Users will experience higher or lower accuracies, depending on atmospheric conditions (e.g., charged particles in the ionosphere and water vapor in the troposphere), obstructions (e.g., buildings and canopy cover), the number and position of satellites in the sky, and the user's latitude (which affects the angle of inclination between the user and the position of geostationary satellites broadcasting correction information). Some of these devices can be paired with an external antenna to improve accuracy. When the external antenna is elevated above obstructions, such as dense canopy, these devices receive a stronger GPS signal and produce more accurate results than devices that lack external antennas. However, none of these devices collect

survey-grade data out of the box; and factors that limit accuracy should always be taken into consideration.

1.2 Objectives

Our objective was to compare and contrast the prices, data transfer mechanisms, and accuracies of GPS devices in the context of tasks performed by USACE Regulatory Project Managers, such as field navigation, verification of wetland delineations, or jurisdictional determinations.

1.3 Approach

In 2016, the Institute for Water Resources surveyed the USACE Regulatory Districts regarding GPS devices commonly used for regulatory purposes. Results showed that a wide variety of devices from three major manufacturers, Garmin, Magellan, and Trimble, were used nationally. The Cold Regions Research and Engineering Laboratory researched the specifications of the most technologically advanced and user-friendly models produced by each manufacturer. The information contained in this report was collected from manufacturer websites and specification sheets, interactions with customer support, current users, and sales representatives.

2 Types of Devices

2.1 Garmin

Garmin devices, designed for fitness and recreational users, are easy to use and are the least expensive of the three major GPS manufacturers described in Table 1. Freeware accessible through ACE-IT's ServiceTrak website (entered through the App Portal) is available for projecting, converting, and viewing Garmin files and for obtaining digital imagery; so it is not necessary to purchase special software (Table 2). High-end models, such as the Montana 680t or the Oregon 750t, are preloaded with 1:100K topographic maps and support proprietary Birdseye Satellite Imagery. These devices use Bluetooth and the Garmin Connect mobile app to transfer data wirelessly to other GPS units or smartphones within a 10 m radius (Garmin 2011, 2016). In addition, the app also transfers tracks data from the GPS to the user's account on the Garmin Connect website when connected via Bluetooth and a smartphone to a wireless network (Garmin Technical Support 2017), enabling Project Managers to comply with Corps data transfer protocol (USACE 2016).

However, Garmin devices also have several drawbacks. The first is that Garmin GPS only transmits tracks data to the internet wirelessly (Garmin Technical Support 2017). Therefore, to comply with USACE cyber security protocol, Project Managers must transfer point and polygon data to the USACE network via a stand-alone airgap computer dedicated to scanning data for malware and viruses before transfer to network computers. Second, real-time accuracy is lower than that of other brands. Garmin Technical Support guarantees an accuracy of 15 m although the average user experiences higher accuracy of 5–10 m (Garmin Technical Support 2017). Practical uses of the Garmin include coarse-grained navigation, such as navigating to a delineated boundary for field verification, and for points where precision is not critical (e.g., "photo point #1 within wetland #4 looking south"). However, this level of accuracy is less useful for other aspects of fieldwork, such as navigating to a precise point along a delineated wetland boundary, mapping polygons, or recording specific points such as "edge of new fill." The Montana series can be used with an external antenna, which could improve accuracy in some situations. But in general, these devices are best used when a high level of accuracy, such as for a delineation or jurisdictional determination, is not required (Table 1).

Table 1. Summary of select specifications for Global Positioning System devices preferred for USACE Regulatory District tasks (n/a = not applicable, μ = micro, and HH = handheld, SD = 4 MB–2 GB memory card, SDHC [Secure Digital High Capacity] = 4 GB–32 GB memory card).

Specifications	Garmin		Magellan	Trimble	
	Montana 680t	Oregon 750t	eXplorist 710 United States	TDC100 Wi-Fi Handheld	Juno 5B Enhanced Wi-Fi Handheld
Global Positioning System					
Average real-time accuracy (m)	5–10	5–10	3–5	1–2	1–2
Compatible with external antenna	Yes	No	No	Yes	Yes
Data transfer via Wi-Fi	No	No	No	Yes, all data	Yes, all data
Data transfer via Bluetooth	Tracks only (.gpx files)	Tracks only (.gpx files)	No	Yes, all data	Yes, all data
Camera (MP)	8	8	3.2	8	8
Background maps	Birdseye Imagery 1:100 K topos	Birdseye Imagery 1:100 K topos	Digital Globe Imagery, Summit Series 1:24 K topos, World Edition, City Series USA	Google/Open Street Maps	Google/Open Street Maps
Device					
Operating system	n/a	n/a	n/a	Android 5.1 “Lollipop”	Windows Embedded HH 6.5
Processor	n/a	n/a	n/a	1.2 GHz	1.0 GHz
Memory (RAM)	n/a	n/a	n/a	2 GB	512 MB
Data storage	8 GB	4 GB	3 GB	8 GB	32 GB
Expansion slots	1 μ SD	1 μ SD	1 μ SD	1 μ SD/SDHC	1 μ SD/SDHC
Screen details (cm; pixels)	10.2; 272 × 480	7.6; 200 × 400	7.6; 200 × 400	13.5; 1280 × 720	10.9; 480 × 800
Display type	Color, transfective sunlight readable dual-orientation touchscreen	Color, transfective touch screen	Color, transfective touch screen	Color, Gorilla Glass, sunlight readable, touch screen	Color, Gorilla Glass, sunlight readable, touch screen
Weight (g)	289–332	210	195	310	450
Battery life (hr)	16	16	16	10	8
Ruggedness					
Ruggedness: withstands drop (m)	not rated	not rated	not rated	1.2	1.2
Impervious to dust?	not rated	not rated	not rated	Yes, completely	Yes, completely
Immersion in water?	up to 1 m	up to 1 m	up to 1 m	up to 1 m	beyond 1 m
Operating temperature (°C)	not rated	not rated	–10 to 60	–20 to 60	–30 to 60
Price					
GSA Advantage (FY17)	\$483–\$673	\$450–\$485	\$655	Not available*	\$1,889

*Retails for \$999 at the Trimble store (<https://store.trimble.com/>)

Table 2. Comparison of data collection and office software Global Positioning System devices preferred for USACE Regulatory District tasks (n/a = not applicable).

Device	External Antenna	Data Collection Software	Office Software	Post-Processed Accuracy (m)
Garmin Oregon 750t	n/a	n/a	Birdseye Imagery: Displays high, medium, and low resolution imagery (subscription fee of \$30/year)	n/a
Garmin Montana 680t	GA 25MCX Remote GPS Antenna (\$31.49)		DRNGPS Freeware: Downloads data from GPS to air gap computer, converts file formats, projects/transforms to NAD83 Basecamp Freeware: Displays and downloads imagery, transfers data and images between GPS and the internet, has limited cloud capability via Garmin Connect App	
Magellan eXplorist 710	n/a	n/a	VantagePoint Freeware: Displays and transfers tracks, waypoints, imagery, topo maps, and multi-media files between the GPS, PC and the internet	1–3
Trimble TDC100 Wi-Fi Handheld	External Antenna GPS & GLONASS compatible (\$39)	Esri Collector for ArcGIS: Collects feature and attribute data, enables navigation, syncs data to Esri's cloud, transforms and projects data (no license fee)	ArcGIS online: Creates and shares maps, views/manages data, converts files, transforms and projects data	n/a
		Terraflex Basic: Collects new feature data (\$250/year) Terraflex Advanced: Imports existing data, enables navigation in field, collects feature and attribute data, edits and maintains data (\$400/year)	Terraflex Cloud Services: Displays and manages data Esri ArcMap plugin: Converts files to .shp or .kml DRNGPS: Used with ArcMap, projects or transforms to NAD83	
Trimble Juno 5B Enhanced Wi-Fi Handheld	External Antenna GPS & GLONASS compatible (\$35)	ArcPad: Creates, edits, and analyzes GIS data, including vector and raster files; browses ArcGIS Online to select templates and projects	ArcGIS Online: Stores templates for ArcPad projects; visualizes, edits and analyzes data	Less than 1–2
		Terraflex Basic: Only collects feature (\$250/year) Terraflex Advanced: Enables navigation in field, collects feature and attribute data, maintains data (\$400/year)	Terraflex Cloud Services: Displays and manages data Esri ArcMap plugin: Converts files to .shp or .kml DRNGPS: Used with ArcMap, projects or transforms to NAD83	

2.2 Magellan eXplorist 710 United States

The eXplorist 710, manufactured by Magellan, was designed for recreational users and vehicle navigation. It is rugged and easy to use (Table 1). World Edition and City Series USA vehicle navigation maps with turn-by-turn routing and Summit Series USA topographic maps are preloaded. It also supports satellite and aerial imagery from Digital Globe. Use of Digital Globe by the USACE is covered by the FedGov License agreement. A CAC login is available at <https://evwhs.digitalglobe.com/myDigitalGlobe/login>. VantagePoint freeware transfers data, maps, and imagery between the eXplorist 710, a PC, and the internet. This software is not approved for use on the USACE network at this time, so installation would require a special request to ACE-IT. Unlike Garmin and Trimble, Magellan does not currently have a workspace in the cloud to which users can upload data. So, data transfer from this GPS to the USACE network is best accomplished via an airgap computer. The eXplorist 710 is fairly inexpensive, and real-time accuracy averages 3–5 m (Magellan 2017). Accuracy cannot be increased as this device is not compatible with any of Magellan's external antennas.

The practical uses of the eXplorist 710 are similar to those of a Garmin although somewhat higher accuracy may make it easier to navigate to a particular mapped polygon for field verification of a delineation. This device is also useful for most photo locations because it records videos and voice notes. It may be best used when medium levels of accuracy are required for delineations and jurisdictional determinations.

2.3 Trimble Juno 5B Enhanced Wi-Fi and TDC100 Wi-Fi Handhelds

The Juno 5B Enhanced Wi-Fi handheld (Juno) and the TDC100 Wi-Fi handheld (TDC100) are Trimble devices that are designed for GPS/GIS professionals, who typically require higher levels of accuracy than recreational users. These are also the most rugged of the five devices described here. Both devices transfer data automatically via Wi-Fi, uploading points, lines, polygons, and photos to the user's account in the Trimble cloud where they can be viewed with Google or Open Street map backgrounds. External antennas are available for both devices, enabling them to receive a stronger GPS signal and to produce more accurate results than a device without an external antenna. Under ideal conditions, the Juno collects data with an average accuracy of 1–2 m in real-time (Trimble 2010). The less expensive TDC100 collects data with an accuracy of 1–2 m less than 1.5 m is considered typical (Trimble 2016).

Data collection software is required for both devices. The Juno is compatible with Trimble's Terraflex and more challenging programs such as TerraSync Professional Edition or Esri's ArcPad. Data collected using Terraflex cannot be post-processed to increase accuracy. Similarly, data collected using ArcPad can be post-processed only if a supported external receiver is connected. However, data collected with TerraSync can be post-processed with Pathfinder Office to increase accuracy. The TDC100 is compatible with the Esri Collector app and Terraflex. Practical uses of these devices include recording points during a delineation or on the edge of new fill. These devices could also map the extent of a wetland polygon or the extent of new fill. Therefore, these devices are best used when high levels of accuracy are needed for delineations, jurisdictional determinations, and enforcement actions.

Using templates from either Terraflex or Esri Collector for ArcGIS, Corps Districts could create customized forms for data collection with required and optional fields. Both apps can be used to navigate in the field, collect feature and attribute data, and view or manage data in the cloud. They differ in regard to data format and transformations. Terraflex currently supports only one coordinate system, WGS84, so a free ArcMap plugin is needed to convert data from Trimble's proprietary format (.ssf) to a feature class and transform to NAD83, the format required for Federal data storage. In contrast, Esri Collector for ArcGIS enables the user to specify a geographic transformation method in advance, which is applied on the fly as data are collected. Of course, the correct method must be chosen for the transformation to be effective. Use of Esri Collector for ArcGIS is covered by the Corps Enterprise License Agreement. It was recently white listed for use on CorpsNet (Blyler 2017). There is currently no Enterprise License for Terraflex, so a license must be purchased each year (Table 2). However, if there is enough interest, perhaps a Corps-wide license, as available for the Esri, could be set up in the future.

3 Recommendations

GPS devices are essential tools used to support the USACE Regulatory mission. If a District Regulatory office wants to purchase GPS units, we recommend it being one of these five, depending on district needs, so that we are all using similar devices and can ensure appropriate levels of training and consistency. These devices will be most useful for regulatory purposes within a few years of the publication date of this report because GPS technology is constantly being upgraded and refined. New technologies will make possible the collection of even higher-resolution data in the field. This report will be updated as these devices become functionally obsolete.

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